INDOOR AIR QUALITY REASSESSMENT

Housatonic Grammar School
Berkshire Hills Regional School District
Pleasant Street
Housatonic, Great Barrington, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
August 2002

Background/Introduction

At the request of Daniel Brown, Superintendent of the Berkshire Regional School District, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), provided assistance and consultation regarding indoor air quality concerns at the Housatonic Grammar School (HGS), Pleasant Street, Great Barrington, Massachusetts. Concerns about poor indoor air quality (IAQ) and increases in symptoms suspected of being associated with IAQ prompted this report. On May 2, 2002, the school was visited by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air assessment. Mr. Feeney was accompanied by Judy Dean of the American Lung Association of Western Massachusetts.

The school is a red brick two-story building built in 1904. The building was renovated approximately 20 years ago, which subdivided the basement and updated the ventilation system. The school contains general classrooms, library, gymnasium/ cafeteria, and various offices. Classroom windows are openable.

Two private consultants have conducted indoor air quality assessments within this school. An evaluation conducted by Eco-Genesis Corp (EGC) in 1992 made the following recommendations:

1. Increase fresh air supply to 20 cubic feet per minute (cfm) per person.
2. Ensure ventilation system operation pursuant to the American Society of Heating, Ventilating and Air-conditioning Engineers (ASHRAE) standards 62-1989 concerning ventilation and standard 55-1981 for Thermal Conditions for Human Occupancies (ASHRAE, 1989).
3. Unblock unit ventilators (univents) in classrooms.
4. Replace water damaged ceiling tiles.

5. Professionally clean and disinfect exterior intakes and ducts.
6. Restrict parking on west side of building.
7. Clean classrooms, including stored items (EGC, 1992).

O'Reilly, Talbot & Okun Associates (OTO), another consultant conducted a follow up evaluation in 2002. Air monitoring conducted by this consultant concluded, "[b]ased on the…indoor air quality survey methodology and parameters as compared to national consensus standards, air quality was found to be acceptable throughout the Housatonic Elementary School (OTO, 2002).

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Water content of gypsum wallboard (GW) was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

This school has a student population of 86 and a staff of approximately 27. Tests were taken during normal operations at the school. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in four out of nineteen areas surveyed, which indicates adequate airflow in most areas of the school.

Fresh air in classrooms throughout the building is provided by unit ventilators (univents) (see Figure 1, Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil and is then provided to the classroom from the univent by motorized fans through a fresh air diffuser on the top of the unit. Univents were obstructed and/or deactivated in a number of areas. To function as designed, univent diffusers and returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate.

The renovations appear to have added a mechanical ventilation system to the building and that the building was originally equipped with a natural gravity exhaust ventilation system (see Picture 2, date unknown). The roof vents were removed and sealed (see Pictures 3 and 4). An exhaust vent was installed in the east and west gables on each side of the building (see Picture 5). Exhaust vents in classrooms are installed in the original wall openings for the natural gravity system. Room 2 was reportedly a focus of indoor air quality concerns. The exhaust ventilation system in this classroom was blocked with a desk, which inhibits airflow to the vent. Without exhaust ventilation, normally occurring indoor pollutants can build up within a classroom and lead to air quality complaints.

During the summer months, ventilation is reportedly supplemented by the use of openable windows in classrooms. The building was designed to use cross-ventilation to provide comfort for building occupants. It is equipped with windows on opposing exterior walls. In addition, the building has hinged windows located above the hallway doors. This hinged window (called a transom) enables the classroom occupant to close the hallway door while maintaining a pathway for airflow. This design allows for airflow to enter an open window, pass through a classroom, pass through the open transom, enter the hallway, pass through the opposing open classroom transom, into the opposing classroom and exit the building on the leeward side (opposite the windward side) (see Figure 2). With all windows and transoms open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or transoms are closed (see Figure 3). Each classroom would have a long pole with a hook that was used to open the hoop latch that locks the transom closed. Most transoms in the 1919 building were closed during the assessment, which can inhibit airflow in the summer.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, these systems must also be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o}F to 78 ^{o}F in order to provide for the comfort of building occupants. Temperature readings ranged from 67^{o} F to 72^{o} F, which were below the BEHA recommended range in some areas (see Tables). In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building ranged from 34 to 41 percent, which was below the BEHA recommended comfort range in most areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Building occupants reported that visible mold growth had occurred in interior wall materials covering foundation walls in the basement, particularly a section of wall covered with Mylar® (see Picture 6). Mylar® is a plastic material that is water impermeable. If the underlying wall materials were to become moistened, the Mylar® would prevent water evaporation, which may result in the production of microbial growth.

Moisture readings of GW were taken by BEHA staff to determine moisture content of building materials. A minimum of three measurements (one beneath the window, one in an adjoining wall between classrooms and one in the hallway wall) were taken in the art room and adjoining basement areas. Moisture readings are listed in the Tables, listing the lowest normal percentage moisture concentration reading and the highest normal percentage moisture concentration reading. Moisture content of GW were within the normal range (0.1 to 0.2 percent) in all areas except for the art room.

The exterior wall along the foundation in the art room had GW with moisture content measurements over $\geq$0.6 percent, which suggests dampening by a water source.
Please note that moisture content of GW measured is a real time measurement of the conditions present in the building on May 2, 2002. Moisture content may increase or decrease dependent on building and weather conditions.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Once mold growth has occurred, disinfection is likely to be ineffective. Please note that the only reliable methods of determining the presence of mold growth in GW are either wipe or bulk samples for analysis by an analytical laboratory experienced in microbiology.

Moisture sources in the indoor environment can originate from several sources. One possible source of moisture in GW may be classroom univents. This does not appear likely since GW is not located near the fresh air supply for the art room univent. GW near univents had moisture content readings within the normal range. The absence of water damaged plaster as well as decreased moisture content in GW in hallway and adjoining walls appears to eliminate moisture sources from plumbing or HVAC system chilled-water pipes. With the location of increased moisture content along the foundation wall, water penetration from rain through the curtain wall/drainage plane and/or inadequate rainwater drainage appear to be the most likely sources.

The HGS was evaluated during a rainstorm. The exterior wall and the tarmac joints were moistened at a height of one foot around the base of the building (see Picture 7). Some areas have moss growing at the base of the exterior wall (see Picture 8). Moss requires a significant source of moisture to exist. Moistening brick, mortar and window frames at the base of the building can lead to water penetration into basement areas, wetting building materials (e.g. GW). The wetting of exterior brick is due to the lack of gutters and downspouts (see Picture 9). The gutter and downspout system was reported by school personnel to have been removed due to the development of ice dams on the roof. Ice dams occur when snow in contact with the roof melts, forming water in the upper section of the roof, which is then refrozen on the lower portion of the roof to form ice. The source of the heat is from the roof that is incidentally heated by air escaping from the occupied spaces. The snow on the upper part of the roof melts, heated by air escaping. As water moves down sections of the roof below 32^{o} F the water freezes forming ice and creating a dam that traps and holds water against the roof shingles. Pooling water can then penetrate through cracks and crevices in roof materials, resulting in wetting of interior building materials.

In order to prevent ice dams, a combination of methods can be used. The floor of the attic space should be insulated to prevent air movement and heat loss from the occupied space. Ridge vents (installed along the roof ridge) can be installed to allow for free exhaust of heat from the attic space. Soffit vents (located beneath the eave in the roof) provide a source of cold outdoor air to replace the heated air that escapes through the ridge vent. This configuration allows for heat to escape so that the attic space has a temperature that is roughly equal to the outdoor temperature, so that the roof materials do not melt snow in contact with the roof. If attic insulation is inadequate, or if ridge and/or soffit vents are sealed, then heat can accumulate in the roof peak and start the ice dam creation cycle.

School staff report that the ductwork for the exhaust ventilation system in this school is not insulated. As air is exhausted through the ductwork, the metal ductwork becomes heated and can then raise the temperature inside the roof. In addition, no soffit or ridge vents could be identified to create roof space ventilation.

Another confounding problem is moistened insulation from ice dams within the attic space. The ability of insulation to prevent temperature transfer is decreased if the material becomes moistened. This loss of temperature transfer prevention can result in more heat transfer into the attic space, creating larger ice dams and more water penetration. Water damaged ceiling plaster was seen on the second floor, which indicates water leaks through the roof/attic space.

Other rainwater drainage conditions are also adversely affecting the building envelope. The western wall has roofs installed over exterior doors (see Picture 10). Rainwater striking these roofs can be directed toward the window frame above the roof, resulting in water penetration and subsequent damage.

The window frame lintel in room 2 appears to have been replaced. An examination of the area below the window found a stone slab with a vertical crack (see Picture 11). The existence of a vertical crack below the window may indicate some shifting in the exterior brickwork, which may create seams around the window allowing for moisture to penetrate into the interior, resulting in water damage to the window frame.

Several classrooms contained a number of plants that are located over univent fresh air diffusers. Plant soil, standing water and drip pans can be potential sources of mold growth. Drip pans should be inspected periodically for mold growth and over-watering should be avoided.

Other Concerns

The interiors of univents in the original building were spot-checked. Walls in which univents are installed have spaces and holes within the air handling cabinet (see Pictures 12 and 13). Of note is the heavy accumulation of dust around the edges of each hole, indicating unfiltered air passage. The existence of these holes allows for air to by-pass the installed filters, resulting in aerosolization of materials (e.g. dust) from the classrooms. In addition, spaces exist around heating pipes that penetrate through the floor. Spaces of this nature can result in the univent drawing air and debris from the wall cavity or crawl space and distributing these materials to the interior of the building.

Univents were equipped with metal racks, into which filter materials are cut to fit (see Picture 14). The material used for filter media in these metal racks provides minimal filtration of respirable particulates that can be distributed by univents. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can reduce the efficiency of the univents due to increased resistance. Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Of note is the use of different products containing volatile organic compounds (VOCs) in the building, (e.g., permanent markers and dry erase markers). Materials such as dry erase markers and dry erase board cleaners contain VOCs, (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), and can be irritating to the eyes, nose and throat. Under the Labeling of Hazardous Art Materials Act (LHAMA), art supplies containing hazardous materials that can cause chronic health effects must be labeled as required by federal law (USC, 1988). The use of art supplies containing hazardous materials that can cause chronic health effects should be limited to times when students are not present and only when adequate exhaust ventilation is available.

A number of classrooms contained upholstered furniture. If relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

The basement of the building contains a floor drain that appears to have a dry trap, which can allow for sewer gas to back up into the building. Sewer gas can be irritating to the eyes, nose and throat.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean around these areas. Dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Exposed fiberglass from missing/damaged ceiling tiles was noted in the library and teacher's room. Missing/damaged ceiling tiles can provide pathways for the movement of drafts, dusts, odors and particulate matter between rooms and floors. Aerosolized dust, particulates and fiberglass can provide sources of eye, skin and respiratory irritation to certain individuals. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving, and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Conclusions/Recommendations

There appear to be several conditions that may adversely effect the indoor environment that involve the school's ventilation system including means for particulates being entrained by the HVAC system and distributed through the building. Inefficient filtration within univents can result in particulate entrainment. In addition, conditions indicate the possibility of water penetration moistening building materials. For these reasons a two-phase remedial approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns within the building. Removal of possible mold contaminated GW requires special care. Recommendation concerning removal of mold contaminated materials are included under the heading **Renovations**.

In view of the findings at the time of the inspection, the following **short-term** recommendations are made:

1. Clean accumulated particulates from the air handling and control cabinets of each univent.
2. Seal all holes in the walls of the univent air handling cabinets to limit filter bypass.
3. Seal wall and pipe floor holes within univent casing.
4. Remove water damaged GW from art room. Recommendations concerning this operation are included under the subsection **Renovations** on page 17.
5. Remove materials blocking the univent fresh air diffusers and/or return vents. Univents must remain clear of obstructions in order for the equipment to function properly.
6. In order to improve indoor air quality, an increase in the percentage of fresh air supply into the univent system may be necessary. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room.
7. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy independent of classroom thermostat control.
8. Clear a three-foot space around all exhaust vents where feasible and reduce stored materials such that airflow is not impeded.
9. Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced.
10. Replace the metal racks with disposable filters. Consider increasing the dust-spot efficiency of HVAC filters.
11. Examine insulation in attic. Replace water damaged sections of insulation, if present.

12. Replace any remaining water-stained wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
13. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
14. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
15. Consider replacing art and school supplies containing materials that require labeling under LHAMA with water-based materials to reduce VOCs in classrooms.
16. Acquire current Material Safety Data Sheets for all products that contain hazardous materials and are used within the building, including office supplies, in conformance with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
17. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
18. Remove plants from the air stream of univent air diffusers. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants.
19. Replace missing/damaged ceiling tiles in the library and teacher's room.

Long Term Recommendation

1. Reinstall gutters along the eaves of all roofs.
2. Examine the feasibility of insulating the exterior of exhaust vent ductwork and motors to decrease heat transmission into the attic space.
3. Consider sealing the skylights in the attic to prevent heat transmission into the attic from solar gain.
4. Examine the feasibility of installing a passive ventilation system (e.g., soffit and ridge vents) in the attic to decrease temperature differentiation in the roof to prevent the future development of ice dams.
5. Examine the junction between the small roofs over exterior doors and the exterior wall for adequacy of flashing and pitch to prevent water penetration into adjacent window frames. If damaged, examine options for improving flashing and pitch.
6. Have a building engineer examine the cracked stone in the exterior wall of room 2 for structural integrity.

Renovations

The following recommendations are made if the building must be occupied during renovations.

1. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.
2. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation-related odors and/or dust(s) problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.

3. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.
4. Disseminate scheduling itinerary to all affected parties. This can be done in the form of meetings, newsletters or weekly bulletins.
5. Deactivate univents in rooms during GW removal. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the school's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).
6. Obtain Material Safety Data Sheets (MSDS') for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).
7. Consult MSDS' for any material applied to the effected area during renovation(s) including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.
8. Seal utility holes, spaces in floor decking and temporary walls to eliminate pollutant paths of migration. Seal holes created by missing tiles in ceiling temporarily to prevent renovation pollutant migration.

9. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.
10. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.
11. Consider changing univent filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.
12. Dispose of contaminated materials in a manner to prevent cross contamination in other sections of the building (US EPA, 2001).
13. Once GW is removed, determine the source of moisture and remediate prior to installation of new GW.

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Figure 2 **Cross Ventilation in a Building Using Open Windows and Transoms**

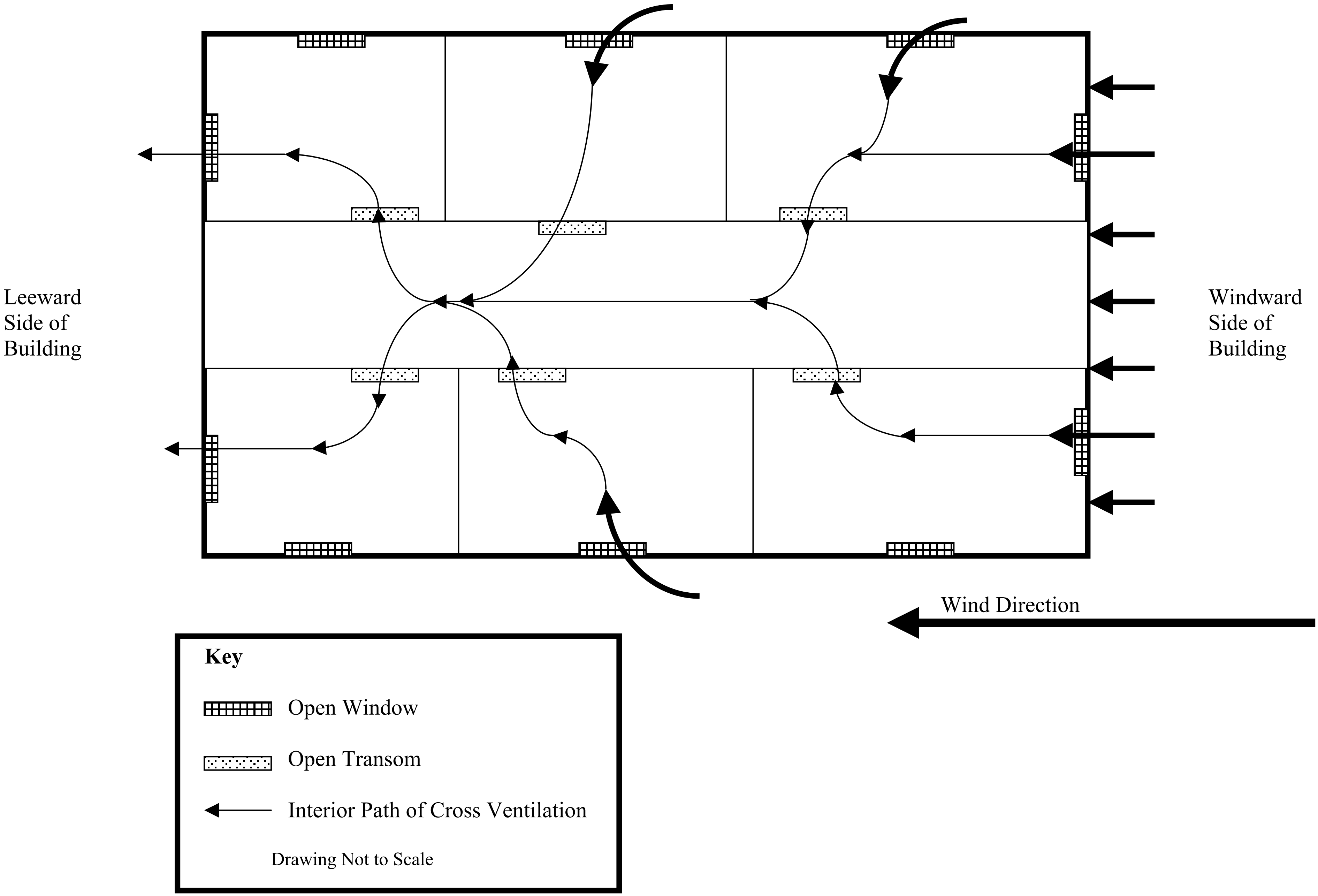
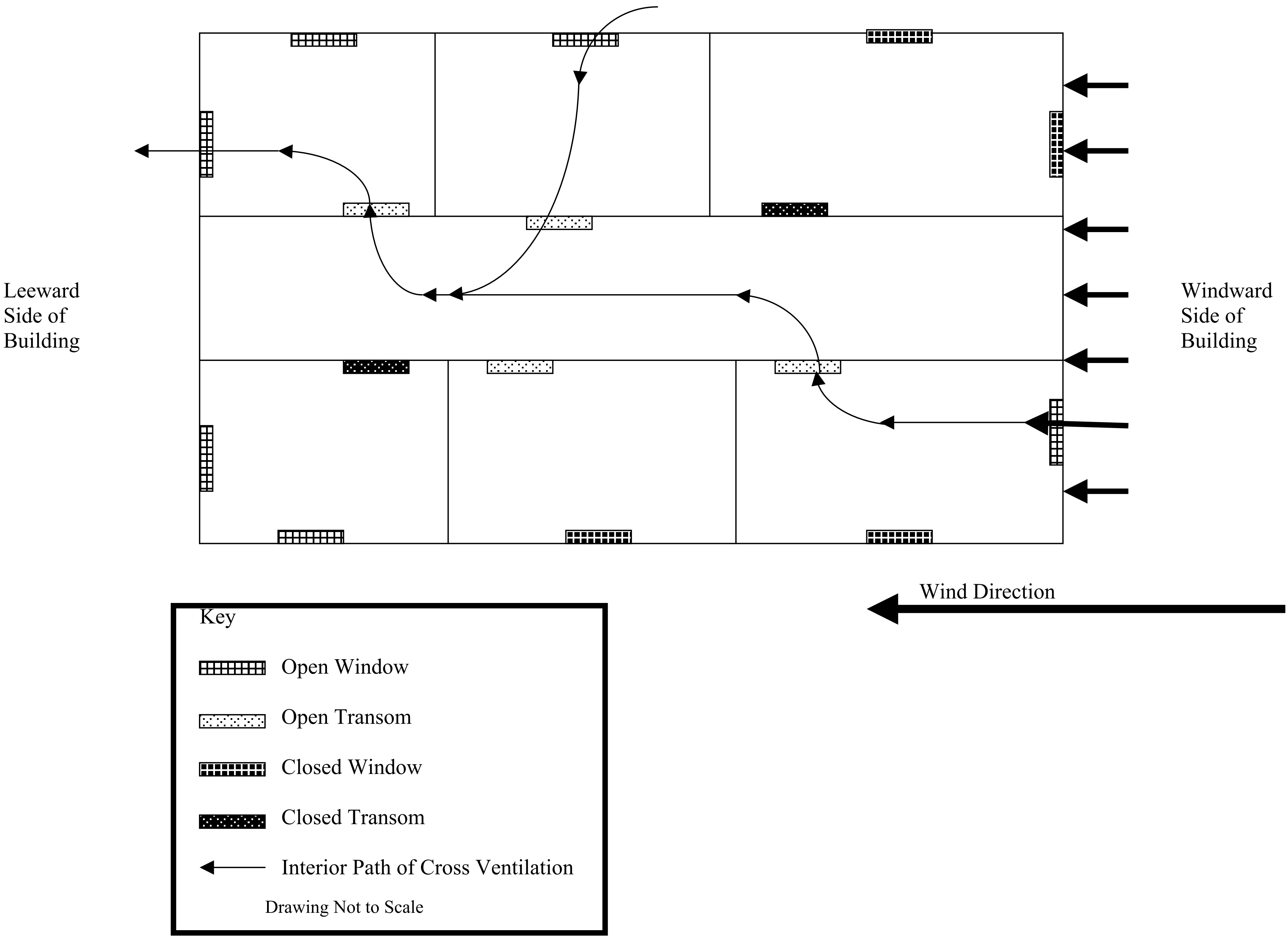


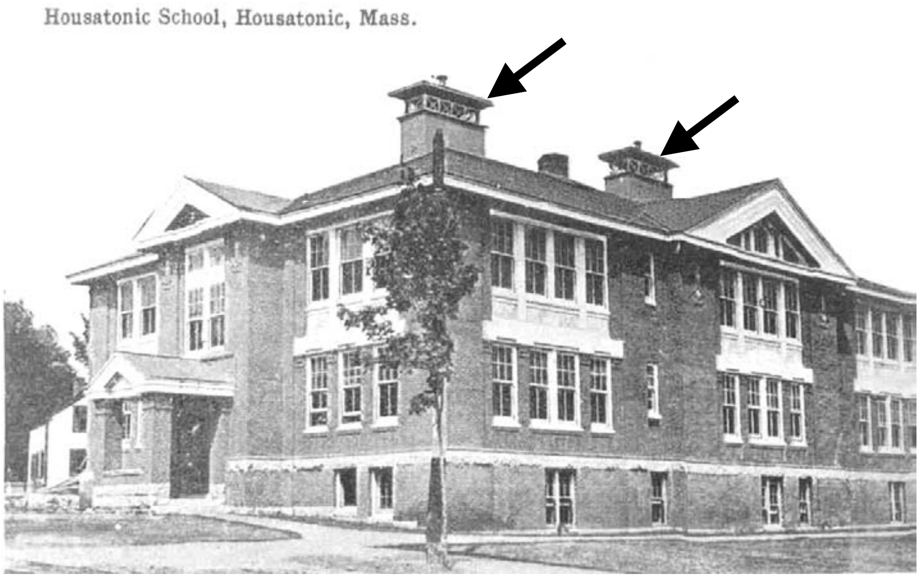
Figure 3 **Inhibition of Cross Ventilation in a Building with Several Windows and Transoms Closed**



Picture 1

Typical Univent (front Cover Removed)

Picture 2



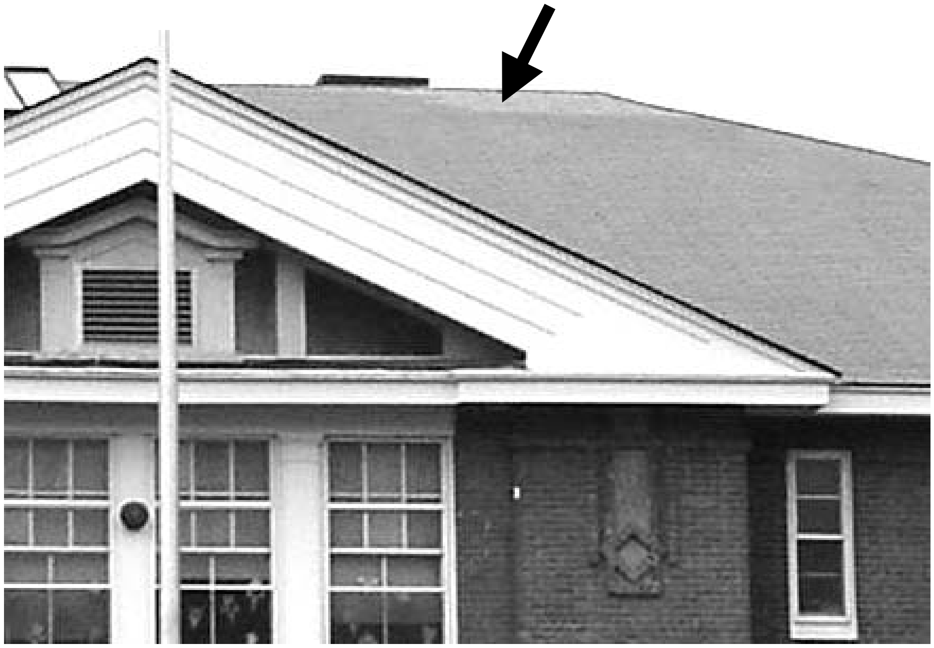
Picture of HES Prior to Ventilation System Renovation, Note Ventilation Shaft Termini on Roof

(Date of picture and photographer unknown, picture is a copy from school flyer)

Picture 3

Current Configuration of Roof

Picture 4

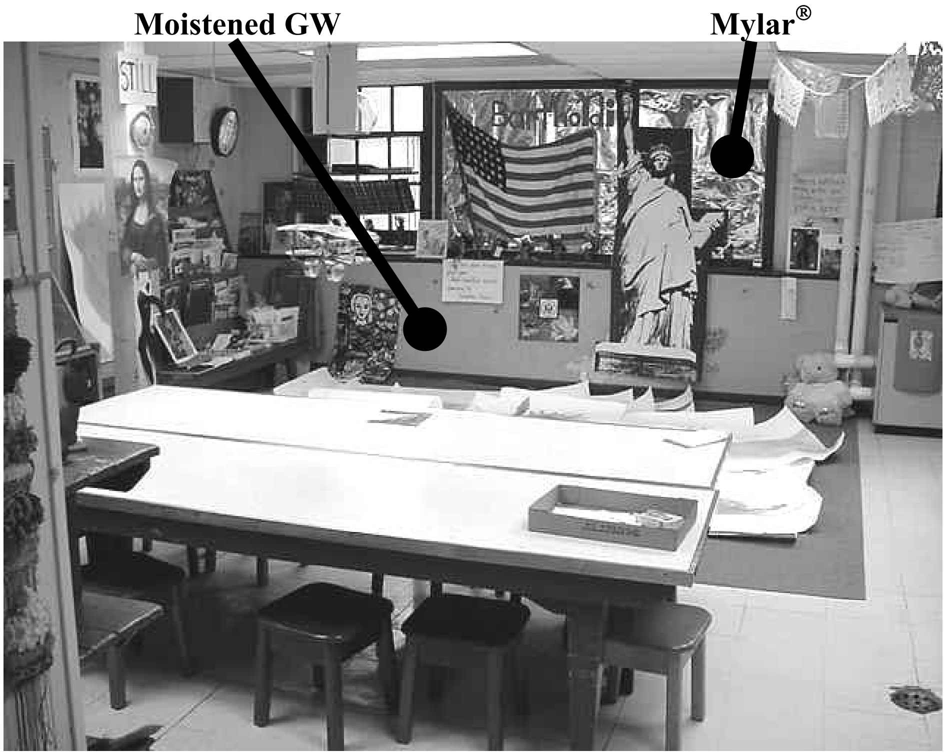


Former Location of North Air Shaft, Note Roof Shingle Color

Picture 5

Gable Installed Exhaust Vent, West wall of HES

Picture 6



Moistened GW wallboard in Art Room

Picture 7

Exterior Wall Moisture during Rain Storm, Note Height of Discoloration (Arrow Denotes Upper Edge of Moistened Brick)

Picture 8

Moss Growth on Exterior Wall

Picture 9

Racks at Roof Eave that Formally Held Gutter

Picture 10

Roof over Exterior Door, West Wall, Note Moisture Pattern on Exterior Brickwork

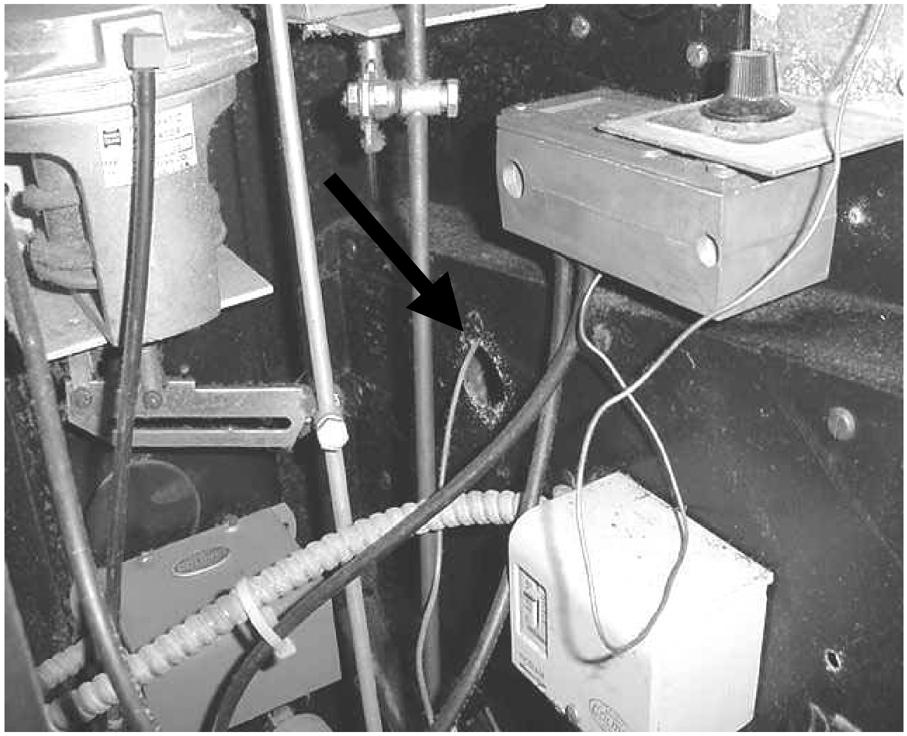
Picture 11

Stone Slab with Vertical Crack below Room 2 window.

Picture 12

Spaces in Univent Air Handling Cavity, Note Dust Accumulation

Picture 13



Spaces in Univent Air Handling Cavity, Note Dust Accumulation

Picture 14

Cut-to-Size Filter Medium in Metal Rack

TABLE 1

Indoor Air Test Results – Housatonic Grammar School, Great Barrington, MA – May 2, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	371	53	47					
Cafeteria	1060	69	40	40+	yes	yes	yes	2 refrigerators, stove
Art Room SW Corner	808	69	37	2	yes	yes	yes	floor drain
Teacher's Room	1259	70	41	5	no	no	yes	exposed fiberglass-CT
Custodial Closet						no	no	
Room 4	575	71	36	0	yes	yes	yes	photocopier, door open
Room 2	825	71	37	16	yes	yes	yes	exhaust blocked by desk, ammonia
Main Office	618	71	36	2	yes	yes	yes	photocopier
Room 3	564	71	35	0	yes	yes	yes	couch, door open
Room 5 inner	598	72	35	0	no	no	yes	door open
Room 5A outer west	555	71	35	2	yes	yes	no	door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Housatonic Grammar School, Great Barrington, MA – May 2, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Room 5B outer north	695	71	34	0	yes	no	no	odor, door open
Basement Hallway north								floor drain
Library	677	67	35	1	no	yes	yes	grates-open heat pipes, exposed fiberglass-CT, door open
Room 12	774	69	40	12	yes	yes	yes	plants, closed transom, door open
Room 10	668	0	39	12	yes	yes	yes	transom closed, door open
Room 8	760	71	37	14	yes	yes	yes	Expo® dry erase cleaner, transom closed, door open
Room 7	873	71	37	15	yes	yes	yes	window and door open, permanent magic marker
Room 9	697	71	35	0	yes	yes	yes	
Room 11	532	70	34	0	yes	yes	yes	plants, peeling paint, water-damaged carpet, door open
Nurse's Office	667	69	37	0	yes	yes	yes	door open
Nurse's Office Restroom						no	yes	exhaust off-light switch activated

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Housatonic Grammar School, Great Barrington, MA – May 2, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 6	533	69	35	2	yes	yes	yes	heat pipe hole, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%